AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

# GCSE CHEMISTRY

**H**

Higher Tier Paper 1

Time allowed: 1 hour 45 minutes

**Materials**

For this paper you must have:
- a ruler
- a scientific calculator
- the periodic table (enclosed).

**Instructions**
- Use black ink or black ball-point pen.
- Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- In all calculations, show clearly how you work out your answer.

| For Examiner's Use | |
|---|---|
| Question | Mark |
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| **TOTAL** | |

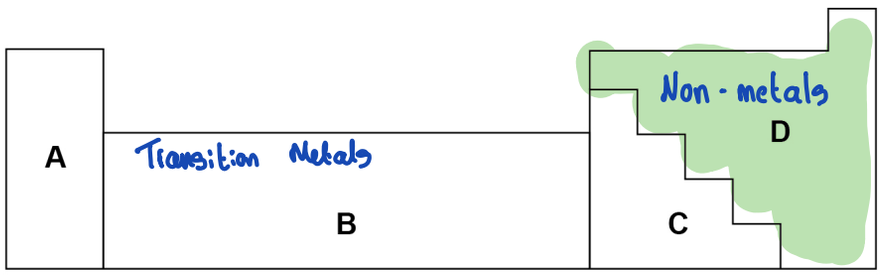
**Information**
- The maximum mark for this paper is 100.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

Do not write outside the box

**0 1** This question is about metals and non-metals.

**Figure 1** shows an outline of part of the periodic table.

**Figure 1**




**0 1 . 1** Element **Q** is a dull solid with a melting point of 44 °C.

Element **Q** does not conduct electricity. ∴ must be a non-metal

Which section of the periodic table in **Figure 1** is most likely to contain element **Q**?

**[1 mark]**

Tick (✓) **one** box.

A ☐ B ☐ C ☐ D ☑

**0 1 . 2** Element **R** forms ions of formula $R^{2+}$ and $R^{3+}$ Multiple oxidation states: Transition Metal.

Which section of the periodic table in **Figure 1** is most likely to contain element **R**?

**[1 mark]**

Tick (✓) **one** box.

A ☐ B ☑ C ☐ D ☐

**0 1 . 3** Give **two** differences between the physical properties of the elements in Group 1 and those of the transition elements.

**[2 marks]**

1 Have lower melting points

2 Are less strong (lower densities)

Do not write outside the box

**0 1 . 4** Complete **Figure 2** to show the electronic structure of an aluminium atom.

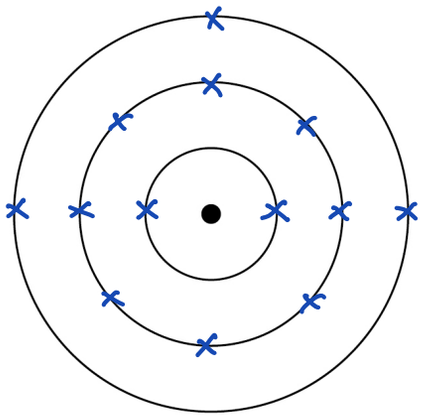
Use the periodic table.

27
Al
aluminium
13

Al :
Atomic No = 13
N° protons = 13
∴ N° electrons = 13

**[1 mark]**

**Figure 2**



1st Shell (max = 2): 2
2nd Shell (max = 8): 8
3rd Shell (max = 8): 3
13

**0 1 . 5** Aluminium is a metal.

Describe how metals conduct electricity.

Answer in terms of electrons.

**[3 marks]**

In a metal, there are delocalised electrons

Electrons carry charge

Electrons move through the structure ∴ conducting electricity.

**0 1 . 6** Name the type of bonding in compounds formed between metals and non-metals.

**[1 mark]**

Ionic

$Na^+$ $Cl^-$
metal non-metal

**Turn over ►**

Do not write outside the box

**0 1 . 7** Magnesium oxide is a compound formed from the metal magnesium and the non-metal oxygen.

Describe what happens when a magnesium atom reacts with an oxygen atom.

You should refer to electrons in your answer.

**[4 marks]**

Magnesium atom loses 2 valence electrons

Oxygen atom gains 2 electrons

2 electrons are transferred

Magnesium ions and Oxygen ions are formed ($Mg^{2+}$) ($O^{2-}$)

13

Group 2

Mg

↓ loses $2e^-$

$Mg^{2+}$

Group 6

O

↓ gains $2e^-$

$O^{2-}$

*Do not write outside the box*

**0 2** Sodium carbonate reacts with hydrochloric acid in an exothermic reaction.

The equation for the reaction is:

$$Na_2CO_3(s) + 2\,HCl(aq) \rightarrow 2\,NaCl(aq) + CO_2(g) + H_2O(l)$$

A student investigated the effect of changing the mass of sodium carbonate powder on the highest temperature reached by the reaction mixture.

**0 2 . 1** Plan a method to investigate the effect of changing the mass of sodium carbonate powder on the highest temperature reached.

**[6 marks]**

Measure a volume of HCl
with a measuring cylinder
Pour HCl into insulated container (polystyrene cup)
Measure the initial temperature of HCl in cup
with a thermometer
Add a weighed mass of $Na_2CO_3$
(measured with a balance)
Measure the highest temperature reached
Repeat with different masses of $Na_2CO_3$
(or add successive masses of $Na_2CO_3$ to same mixture)

Repeat the whole investigation

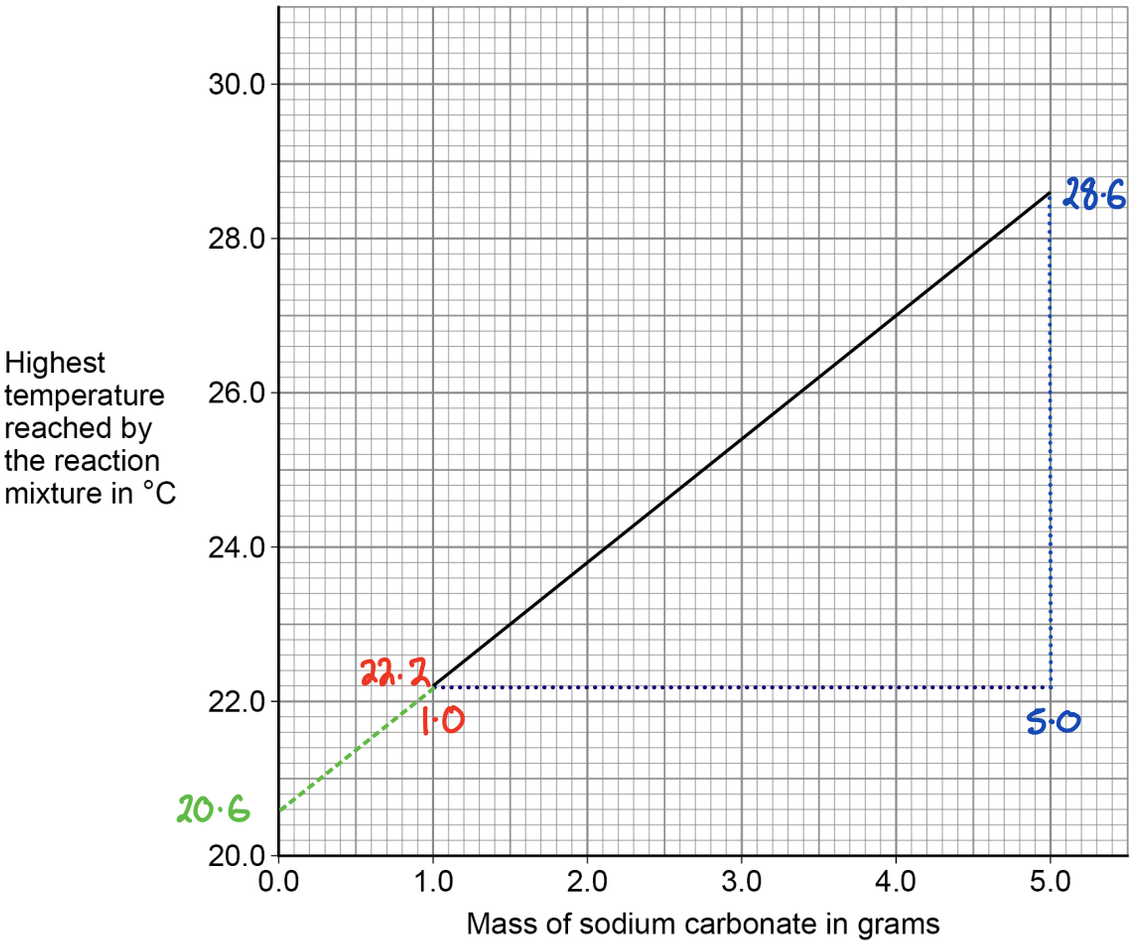
Use the same starting temperature
Use the same volume of HCl each time
Use the same concentration of HCl each time

**Turn over ►**

*Do not write outside the box*

**Figure 3** shows a line of best fit drawn through the student's results.

**Figure 3**



*Do not write outside the box*

**0 2 . 2** Determine the gradient of the line of best fit in **Figure 3**.

Use the equation:

$$\text{Gradient} = \frac{\text{Change in highest temperature}}{\text{Change in mass}}$$

Give the unit.

**[5 marks]**

Gradient $= \frac{\Delta y}{\Delta x} =$ Change in highest temperature / Change in mass

Point 1 $(x_1, y_1) = 1.0\,g$, $22.2\,^{\circ}C$

Point 2 $(x_2, y_2) = 5.0\,g$, $28.6\,^{\circ}C$

Change in $y = \Delta y = y_2 - y_1 = 28.6\,^{\circ}C - 22.2\,^{\circ}C = 6.4\,^{\circ}C$

Change in $x = \Delta x = x_2 - x_1 = 5.0\,g - 1.0\,g = 4.0\,g$

Gradient $= \frac{\Delta y}{\Delta x} = \frac{6.4\,^{\circ}C}{4.0\,g} = 1.6\,^{\circ}C\,g^{-1}$ or $^{\circ}C/g$

Gradient = 1.6 Unit °C/g

**0 2 . 3** The initial temperature of the reaction mixture is where the line of best fit would meet the *y*-axis.

Determine the initial temperature of the reaction mixture.

Show your working on **Figure 3**.

**[2 marks]**

Initial temperature of the reaction mixture = 20.6 °C

**Turn over ►**

*Do not write outside the box*

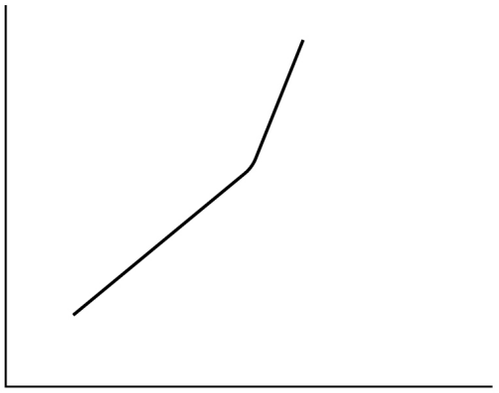
**0 2 . 4** Another student repeated the investigation but added sodium carbonate until the sodium carbonate was in excess.

Which sketch graph shows the results obtained when sodium carbonate was added until in excess?

**[1 mark]**

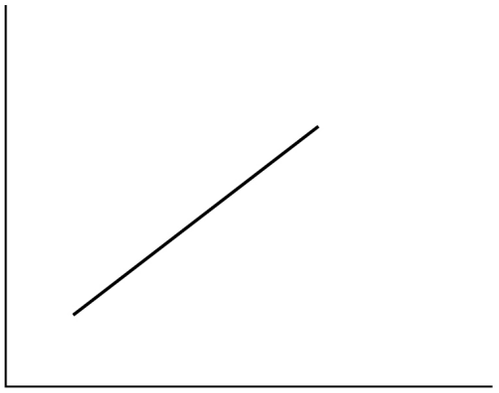
Tick (✓) **one** box.

**A**



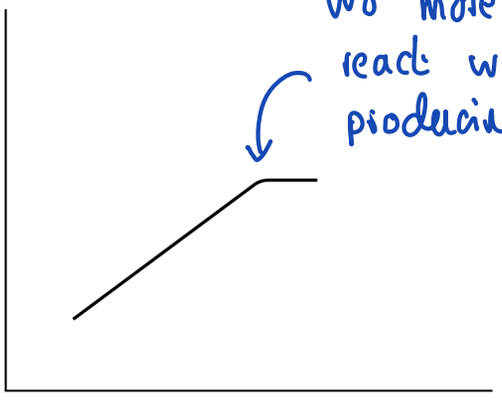

☐

**B**




☐

**C**



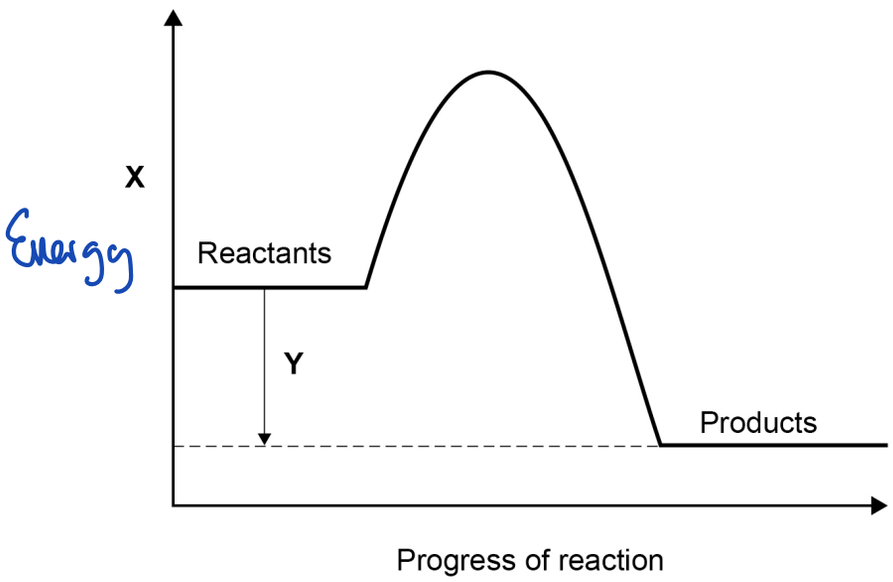

No more HCl to react with excess $Na_2CO_3$ producing heat.

☑

*Do not write outside the box*

**Figure 4** shows a reaction profile for the reaction of sodium carbonate with hydrochloric acid.

**Figure 4**




**0 2 . 5** What do labels **X** and **Y** represent on **Figure 4**?

**[2 marks]**

**X** Energy

**Y** Overall Energy change

Heat given out
ΔH = -'ve

**0 2 . 6** How does the reaction profile show that the reaction is exothermic?

Use **Figure 4**.

**[1 mark]**

The energy level of the products is below (lower than) the energy level of the reactants

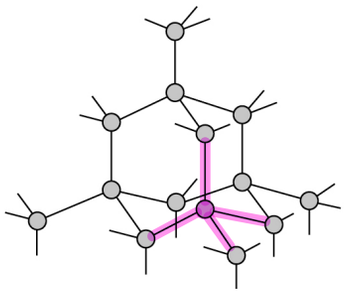
17

*Do not write outside the box*

**0 3** This question is about different forms of carbon.

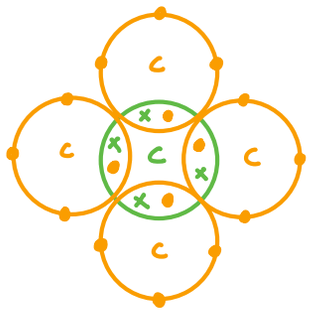
**Figure 5** represents the structure of diamond.

**Figure 5**



**Key**

● Carbon atom




**0 3 . 1** Describe the structure and bonding of diamond.

**[3 marks]**

Giant structure
Formed from covalent bonds
Each carbon atom forms 4 bonds.

**0 3 . 2** Explain why diamond has a very high melting point.

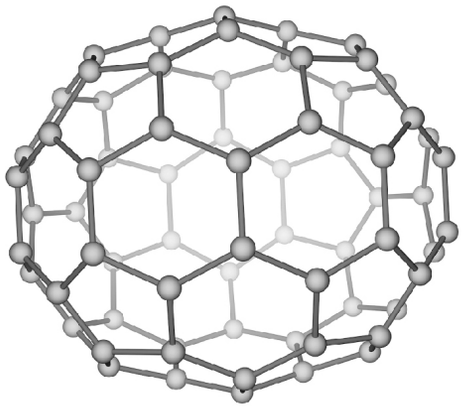
**[3 marks]**

Covalent bonds are very strong
Many covalent bonds need to be broken
So a lot of energy is required
∴ Very high melting point.

*Do not write outside the box*

**Figure 6** represents the molecule $C_{70}$

**Figure 6**



**0 3 . 3** What is the name of this type of molecule?

**[1 mark]**

Tick (✓) **one** box.

| | | |
|---|---|---|
| Fullerene | ✓ | |
| Graphene | | - 2D flat sheet |
| Nanotube | | tube |
| Polymer | | Long chain molecule. |

**0 3 . 4** Molecules such as $C_{70}$ can be used in medicine to move drugs around the body.

Suggest **one** reason why the $C_{70}$ molecule is suitable for this use.

**[1 mark]**

It's hollow to contain the drug. Unreactive and non-toxic

**Turn over ►**

Do not write outside the box

**0 3 . 5** Calculate the number of $C_{70}$ molecules that can be made from one mole of carbon atoms.

The Avogadro constant = $6.02 \times 10^{23}$ per mole

**[3 marks]**

N° of C atoms in 1 mole = $6.02 \times 10^{23}$ C atoms

N° of C atoms in $C_{70}$ = 70

∴ N° $C_{70}$ molecules = $\frac{6.02 \times 10^{23}}{70}$

= $8.6 \times 10^{21}$

Number of molecules = $8.6 \times 10^{21}$

11

*Do not write outside the box*

**0 4** This question is about zinc and compounds of zinc.

A student produces pure crystals of zinc chloride by reacting zinc oxide with hydrochloric acid.

The equation for the reaction is:

$$ZnO(s) + 2\,HCl(aq) \rightarrow ZnCl_2(aq) + H_2O(l)$$

**0 4 . 1** The student adds zinc oxide to hydrochloric acid until the zinc oxide is in excess.

Give **one** observation that the student could make to show that the zinc oxide is in excess.

**[1 mark]**

There is solid remaining as the ZnO no longer dissolves

**0 4 . 2** Why is excess zinc oxide used rather than excess hydrochloric acid?

**[1 mark]**

Excess ZnO can be filtered off.

**0 4 . 3** Name **one other** compound that the student could add to hydrochloric acid to produce zinc chloride.

**[1 mark]**

Zinc carbonate ($ZnCO_3$) or zinc hydroxide $Zn(OH)_2$

**0 4 . 4** Describe how the student should obtain crystals of zinc chloride from a solution of zinc chloride.

**[2 marks]**

Heat the solution until the crystallisation point is reached.

Leave solution to cool, crystallise.

**Turn over ►**

*Do not write outside the box*

Zinc chloride is also produced in a displacement reaction between zinc and copper chloride solution.

The equation for the reaction is:

$$Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$$

**0 4 . 5** Complete the ionic equation for this reaction.

**[1 mark]**

$$Zn + \underline{Cu^{2+}} \rightarrow Zn^{2+} + \underline{Cu}$$

**0 4 . 6** Why is zinc described as being oxidised in this reaction?

**[1 mark]**

Zinc atom loses 2 electrons $(Zn \rightarrow Zn^{2+})$

Oxidation
Is
Loss
Reduction
Is
Gain

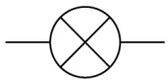
Do not write outside the box

**0 4 . 7** Zinc and copper can be used with another substance to produce electricity.

Complete **Figure 7** to show how zinc, copper and another substance can be used to light a lamp.

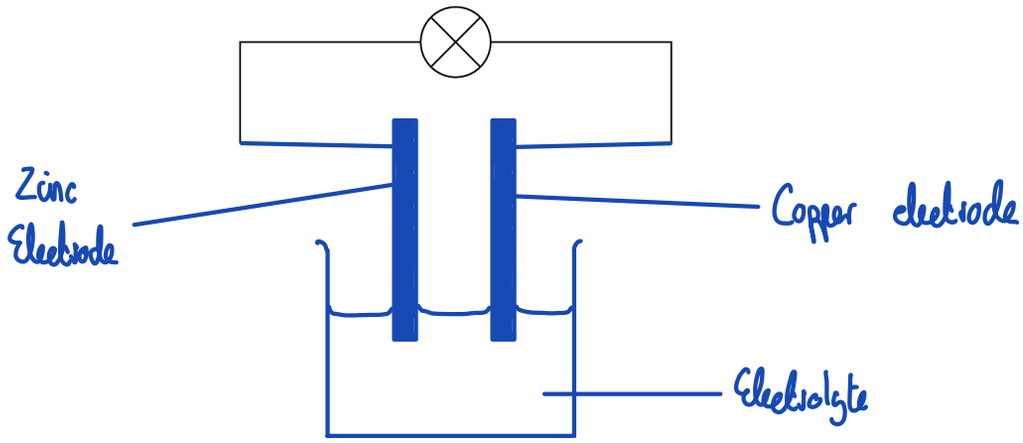
Label:

- zinc
- copper
- the other substance used.

The symbol  represents the lamp.

**[3 marks]**

**Figure 7**




10

**Turn over for the next question**

*Do not write outside the box*

**0 5** This question is about groups in the periodic table.

The elements in Group 1 become more reactive going down the group.

Rubidium is below potassium in Group 1.

**0 5 . 1** Rubidium and potassium are added to water.

Predict **one** observation you would see that shows that rubidium is more reactive than potassium.

**[1 mark]**

More vigorous bubbling reaction
brighter flame for rubidium.

**0 5 . 2** Explain why rubidium is more reactive than potassium.

**[3 marks]**

Rubidium's outer (valence) shell is further from nucleus

So - there is less electrostatic attraction between the nucleus and the outer electron

∴ the outer electron in rubidium is lost more easily

**0 5 . 3** Complete the equation for the reaction of rubidium with water.

You should balance the equation.

**[3 marks]**

$2\,Rb + 2\,H_2O \rightarrow 2\,RbOH + H_2$

Do not write outside the box

The noble gases are in Group 0.

**0 5 . 4** Which is a correct statement about the noble gases?

**[1 mark]**

Tick (✓) **one** box.

- The noble gases all have atoms with eight electrons in the outer shell. ☐
- The noble gases have boiling points that increase going down the group. ☑ ✓
- The noble gases have molecules with two atoms. ☐
- The noble gases react with metals to form ionic compounds. ☐

bigger atoms
more electrons
↑ forces

**0 5 . 5** **Table 1** shows information about the three isotopes of neon.

**Table 1**

| Mass number | Percentage abundance (%) |
|---|---|
| 20 | 90.48 |
| 21 | 0.27 |
| 22 | 9.25 |

Calculate the relative atomic mass ($A_r$) of neon.

Give your answer to 3 significant figures.

**[3 marks]**

$A_r = \frac{(90.48 \times 20) + (0.27 \times 21) + (9.25 \times 22)}{100}$

$= \frac{1809.6 + 5.67 + 203.5}{100} = \frac{2018.77}{100}$

$= 20.188 = 20.2$

Relative atomic mass (3 significant figures) = 20.2

11

**Turn over ►**

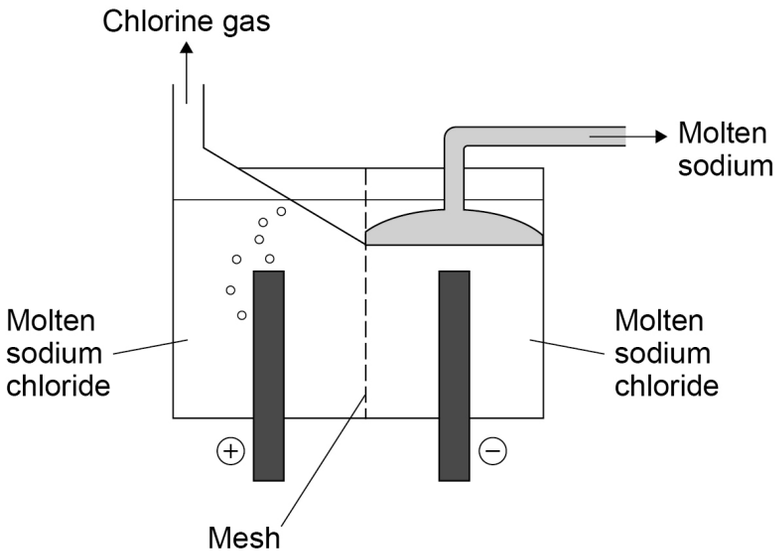
*Do not write outside the box*

**0 6** This question is about electrolysis.

Molten sodium chloride is electrolysed in an industrial process to produce sodium.

**Figure 8** shows a simplified version of the electrolysis cell used.

**Figure 8**




**0 6 . 1** Which is the correct half equation for the production of sodium?

**[1 mark]**

Tick (✓) **one** box.

$Na + e^- \rightarrow Na^+$ ☐

$Na \rightarrow Na^+ + e^-$ ☐

$Na^+ + e^- \rightarrow Na$ ☑

$Na^+ \rightarrow Na + e^-$ ☐

*Do not write outside the box*

A mesh is used to keep the products of the electrolysis apart.

**0 6 . 2** Suggest **one** reason why the products of the electrolysis must be kept apart.

**[1 mark]**

To stop the products reacting to reform sodium chloride.

**0 6 . 3** Which type of particle passes through the mesh in the electrolysis of molten sodium chloride?

**[1 mark]**

Tick (✓) **one** box.

- Atom ☐
- Electron ☐
- Ion ☑
- Molecule ☐

**Question 6 continues on the next page**

Do not write outside the box

Aqueous sodium chloride solution is electrolysed in a different industrial process.

Two gases and an alkaline solution are produced.

**0 6 . 4** Which **two** ions are present in aqueous sodium chloride solution in addition to sodium ions and chloride ions?

**[2 marks]**

1 hydrogen $H^+$

2 hydroxide $OH^-$

**0 6 . 5** Name the alkaline solution produced.

**[1 mark]**

sodium hydroxide

**0 6 . 6** Explain how the alkaline solution is produced.

You should refer to the processes at the electrodes.

**[3 marks]**

Sodium ions and hydroxide ions are left in solution, because:

Hydrogen ions are reduced at -ve electrode to form hydrogen ($2H^+ + 2e^- \rightarrow H_2$)

Chloride ions are oxidised at +ve electrode to form chlorine ($2Cl^- \longrightarrow Cl_2 + 2e^-$)

9

*Do not write outside the box*

**0 7** This question is about silicon and compounds of silicon.

**0 7 . 1** The reactivity series sometimes includes non-metals such as carbon, hydrogen and silicon.

Silicon can be extracted by reducing silicon dioxide with different substances.

The equation for one possible reaction is:

$$2\,C(s) + SiO_2(s) \rightarrow Si(s) + 2\,CO(g)$$

Explain what this reaction shows about the position of silicon in the reactivity series.

**[2 marks]**

The reaction shows that silicon is less reactive than carbon.
Because carbon displaces Si from $SiO_2$

**0 7 . 2** Aluminium also reduces silicon dioxide.

Carbon is used rather than aluminium to reduce silicon dioxide because carbon is cheaper than aluminium.

Carbon can be obtained by heating coal.

Aluminium is obtained from aluminium oxide.

Explain why aluminium is more expensive than carbon.

**[2 marks]**

More energy is needed to obtain aluminium, because aluminium is obtained from aluminium oxide ($Al_2O_3$) by electrolysis. Less energy to dig coal from ground and heat it.

Do not write outside the box

Magnesium also reduces silicon dioxide.

The equation for the reaction is:

$$2\,Mg(s) + SiO_2(s) \rightarrow Si(s) + 2\,MgO(s)$$

**0 7 . 3** Give **one** reason why the products are difficult to separate if magnesium is used to reduce silicon dioxide.

**[1 mark]**

Both products are solid.
(previously, one was a gas!)

**0 7 . 4** Calculate the minimum mass in grams of magnesium needed to completely reduce 1.2 kg of silicon dioxide.

Relative atomic masses ($A_r$): O = 16 Mg = 24 Si = 28

**[5 marks]**

$2\,Mg + SiO_2 \rightarrow Si + 2\,MgO$ (2 : 1)

x 1.2 kg.

N° of moles of $SiO_2$ in 1.2 kg ?

RMM $SiO_2$ = $28 + (16 \times 2) = 60\ g\ mol^{-1}$

$n(SiO_2)$ = 1.2 kg ⇒ $1200\ g = \frac{1200\ g}{60\ g\ mol^{-1}} = 20\ mol$

1 mol of $SiO_2$ needs 2 mol Mg

∴ 20 mol " " $2 \times 20$ " " = 40 mol Mg

Mass of 40 mol of Mg :

RAM Mg = $24\ g\ mol^{-1}$

Minimum mass of magnesium = 960 g

Mass Mg = $24\ g\ mol^{-1} \times 40\ mol$

= 960 g

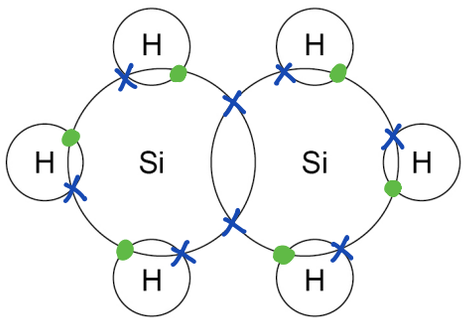
Do not write outside the box

$Si_2H_6$ is a covalent compound of silicon and hydrogen.

**0 7 . 5** Complete **Figure 9** to show the outer shell electrons in a molecule of $Si_2H_6$

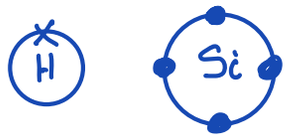
**[1 mark]**

**Figure 9**




Group 1 Group 4

H Si




**0 7 . 6** $Si_2H_6$ reacts with oxygen.

The equation for the reaction is:

1 mol gas ≡ 24 $dm^3$

$$2\,Si_2H_6(g) + 7\,O_2(g) \rightarrow 4\,SiO_2(s) + 6\,H_2O(g)$$

2 : 7

30 $cm^3$ of $Si_2H_6$ is reacted with 150 $cm^3$ (an excess) of oxygen.

Calculate the total volume of gases present after the reaction.

All volumes of gases are measured at the same temperature and pressure.

**[4 marks]**

Volume of $O_2$ needed for 30 $cm^3$ $Si_2H_6$ to react:

$30\ cm^3 \times \frac{7}{2} = 105\ cm^3$

Volume of $O_2$ left over = $150 - 105 = 45\ cm^3$

Volume of $H_2O(g)$ produced:

$30\ cm^3 \times \frac{6}{2} = 90\ cm^3$

Total volume of gases = $45\ cm^3 + 90\ cm^3 = 135\ cm^3$

Volume of gases = 135 $cm^3$

15

Do not write outside the box

**0 8** This question is about acids and alkalis.

**0 8 . 1** Explain why the pH of an acid depends on:

- the strength of the acid
- the concentration of the acid.

**[4 marks]**

pH: pH depends on $H^+$ concentration
Higher $[H^+]$, lower pH

Strength
Stronger the acid, greater the ionisation in solution
Stronger the acid, lower the pH.

Concentration
Higher the concentration of acid, more acid in same volume
Higher the concentration, more $H^+$, ∴ lower the pH

**0 8 . 2** A student titrated 25.00 $cm^3$ of hydrochloric acid with 0.100 $mol/dm^3$ barium hydroxide solution.

**Table 2** shows the results.

**Table 2**

| **Titration number** | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Volume of barium hydroxide solution used in $cm^3$** | 23.90 | 23.45 | 23.55 | 23.55 | 23.45 |

outlier

The student calculated the volume of barium hydroxide solution to be used in the titration calculation as 23.50 $cm^3$.

Explain why the student used a volume of 23.50 $cm^3$ of barium hydroxide solution in the titration calculation.

**[2 marks]**

23.90 is an anomalous result, so not used in calculating the mean. Only results 2-5 used.

$$\text{mean} = \frac{23.45 + 23.55 + 23.55 + 23.45}{4} = 23.50\ cm^3$$

Do not write outside the box

**0 8 . 3** 25.00 $cm^3$ of the hydrochloric acid reacted with 23.50 $cm^3$ of the 0.100 $mol/dm^3$ barium hydroxide solution.

The equation for the reaction is:

$$2\,HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2\,H_2O(l)$$

Calculate the concentration of the hydrochloric acid in $mol/dm^3$.

**[4 marks]**

N° moles of $Ba(OH)_2$ = $\frac{23.50\ cm^3}{1000} \times 0.1\ mol\ dm^{-3}$

$= 2.35 \times 10^{-3}$ mol

2 mol HCl react with 1 mol $Ba(OH)_2$

∴ No mols HCl = $2.35 \times 10^{-3}$ mol × 2

$= 4.7 \times 10^{-3}$ mol

Concentration HCl = $\frac{\text{moles}}{\text{volume}} = \frac{4.7 \times 10^{-3}}{\left(\frac{25}{1000}\right)} = 0.188\ mol\ dm^{-3}$

Concentration of the hydrochloric acid = 0.188 $mol/dm^3$

**Question 8 continues on the next page**

Another student titrated sulfuric acid with barium hydroxide solution.

The equation for the reaction is:

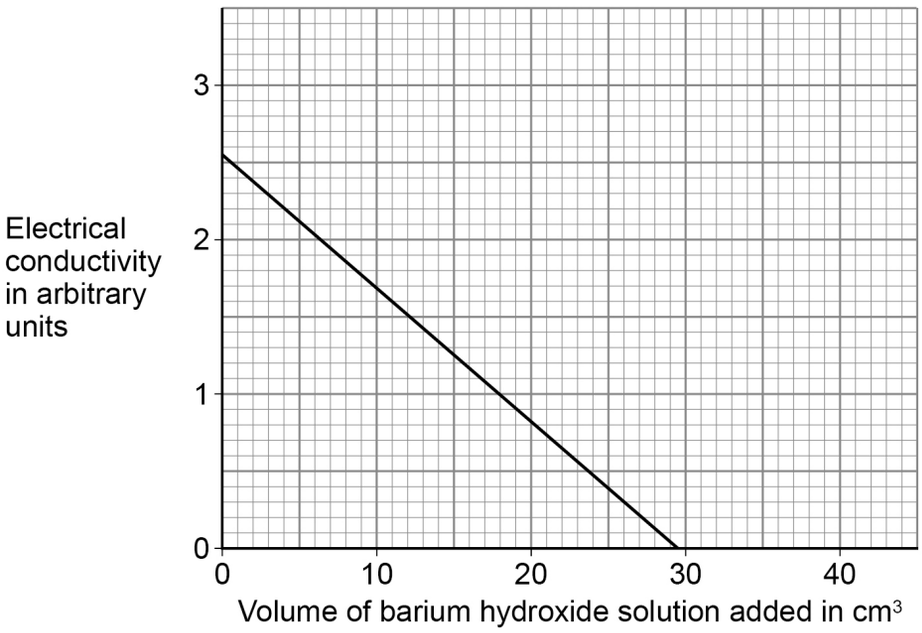
$$H_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$$

The student measured the electrical conductivity of the mixture during the titration.

The better a conductor, the higher the electrical conductivity value.

**Figure 10** shows the results.

**Figure 10**




**0 8 . 4** Explain why the electrical conductivity of the mixture was zero when the sulfuric acid had just been neutralised.

Use the equation for the reaction.

Refer to ions in your answer.

**[3 marks]**

$H_2SO_4 + Ba(OH)_2 \rightarrow BaSO_{4(s)} + 2H_2O_{(l)}$

$2H^+ \; SO_4^{2-} \quad Ba^{2+} \; 2OH^-$ precipitate

When $H_2SO_4$ is neutralised, all of the ions have been used to form solid precipitate $BaSO_4$ and $H_2O$.

∴ No ions free to move, conductivity = 0

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**0 8 . 5** The student then added a further 10 $cm^3$ of barium hydroxide solution.

The electrical conductivity of the mixture increased.

Give **one** reason why.

**[1 mark]**

The mixture now contains $Ba^{2+}$ and $2\ OH^-$ ions so is conductive again.

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**END OF QUESTIONS**

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